PNEUMATIC FRACTURING/SOIL VAPOR EXTRACTION PILOT TEST WORK PLAN

AT THE GRANVILLE SOLVENTS SITE GRANVILLE, OHIO

Submitted to

The United States Environmental Protection Agency
Emergency Response Branch
Region V
Chicago, Illinois 60673

Developed for the

Granville Solvents PRP Group
One Columbus
10 West Broad Street
Columbus, Ohio 43215-3435

April 14, 2000

M&E Metcalf & Eddy
An Air & Water Technologies Company

2800 Corporate Exchange Drive, Suite 250
Columbus, Ohio 43231
(614) 890-5501

M&E
AQUA ALLIANCE

April 14, 2000

Mr. Kevin Adler, Remedial Project Coordinator
U.S. Environmental Protection Agency, Region 5
Office of Superfund, Remedial & Enforcement Response Branch
77 West Jackson Boulevard
Chicago, Illinois 60604-3590

**Subject: Granville Solvents Site Removal Action
Pilot Test Work Plan**

Dear Mr. Adler:

Attached to this correspondence is the Pneumatic Fracturing/Soil Vapor Extraction Pilot Test Work Plan for the Granville Solvents Site. This Work Plan is for your information. The current schedule for the implementation of this Work Plan is attached for your use. We intend to attempt to schedule the pilot test to begin during the week of April 24 or May 1, 2000.

If you have questions regarding this submittal, please contact Mr. Michael Raimonde or me at (614) 890-5501.

Respectfully,

METCALF & EDDY OF OHIO, INC.

Gerald R. Myers
Vice President/Project Coordinator

cc: B. Pfefferle, Chairman - GSS PRP Group
M. Raimonde, M&E

Metcalf & Eddy
2800 Corporate Exchange Drive, Suite 250
Columbus, OH 43231
Tel: 614 890 5501 Fax: 614 890 7421

an affiliate of VIVENDI

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614-890-5501

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1.0 INTRODUCTION

The Administrative Order on Consent (AOC) between the U.S. EPA and a group of potentially responsible parties at the Granville Solvents Site (GSS PRP Group) requires the completion of certain Removal Actions at the Granville Solvents Site (Site). These Removal Actions include the installation of a pump and treat system to halt migration of groundwater contamination toward the Village of Granville municipal wellfield, reinstatement of the capacity of the Village of Granville production well, PW-1, and treatment of soils to required levels so that no groundwater beneath the soils will become contaminated above the groundwater No Further Action levels. To date the GSS PRP Group has installed and is operating a groundwater pump and treat system and has provided a new production well for the Village of Granville.

The Engineering Evaluation/Cost Analysis (EE/CA, August 1999) addressed the soil treatment requirements of the AOC. Previous investigations have characterized soils and groundwater conditions. These data have been evaluated, and the extent and distribution of contaminants in soil and groundwater have been defined. The results of the investigations indicate that chlorinated and non-chlorinated volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) listed in this plan have been detected at the Site. The compounds in the soil are primarily located in the vicinity of the warehouse building. The distribution of contaminants in the soil takes the shape of an inverted cone, with the smallest area of impact at or near the surface and the larger area of impact at or near the water table.

A detailed analysis of the Site conditions was presented in the EE/CA (August 1999). This analysis determined that, to meet the requirements of the AOC and to minimize the time necessary to operate and maintain the existing pumping system, it is necessary to treat soil to the treatment criteria of 5,530 μg/kg for PCE and 6,670 μg/kg for TCE. In doing so, the requirements of the AOC will have been met in an efficient and cost effective manner.

Five alternatives were identified as potential Removal Actions that would reduce the concentrations of PCE and TCE in the soil to below soil treatment criteria. Each alternative was evaluated based on the NCP criteria and the Superfund Accelerated Cleanup Model (SACM) guidance. For the chemicals of concern present at the Site, the remedies are not mutually exclusive. Rather, the properties of the chemicals of concern are similar, which allows all of the chemicals of concern to be addressed using one technology. The results of this evaluation indicate that the best alternative is pneumatic fracturing of the soils and soil vapor extraction (SVE).

The U.S. EPA has approved an Action Memorandum dated March 8, 2000, which was received by the Granville Solvents PRP Group on March 15, 2000, that provides approval of the selected Removal Action of pneumatic fracturing of soils and soil vapor extraction.

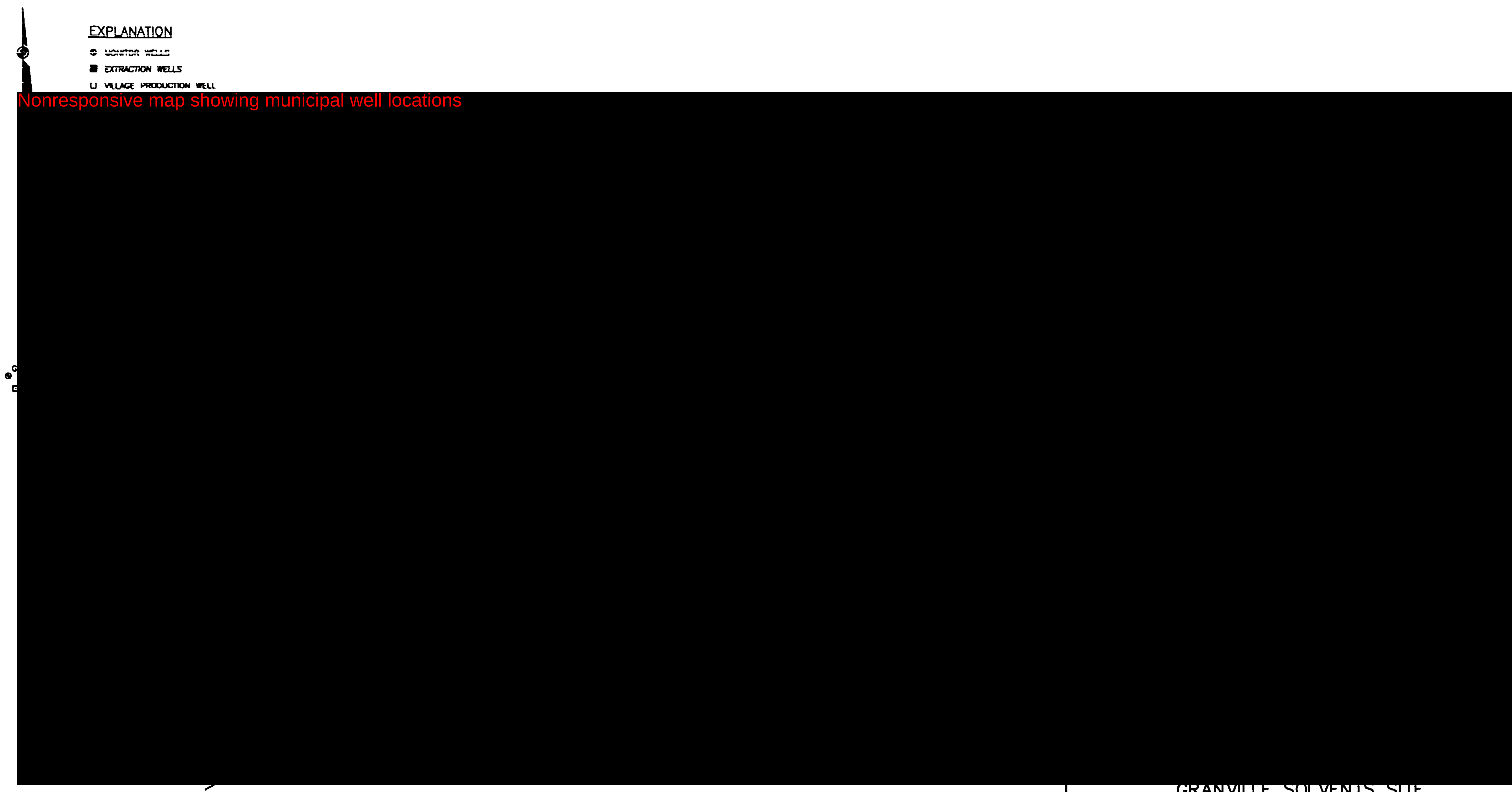
Although pneumatic fracturing-enhanced soil vapor extraction has been used successfully at many sites throughout the country, its site-specific performance must be evaluated prior to full-scale implementation. An evaluation is required to verify that the Site conditions are compatible with the technology and that the technology will adequately reduce soil contaminant levels below the soil treatment criteria. This pilot test work plan describes certain activities that shall be employed to conduct this evaluation. The pilot test shall be conducted by Metcalf & Eddy and ARS Technologies, a technology vendor that holds certain patents regarding pneumatic fracturing.

Detailed data and information may be found in the following reports:

- Metcalf & Eddy, Inc., 1996. Soil Data Report for the Granville Solvents Site in Granville, Ohio; for the Granville Solvents Site PRP Group.
- Metcalf & Eddy, Inc., 1999. Engineering Evaluation/Cost Analysis for the Treatment of Impacted Soils at the Granville Solvents Site, Granville, Ohio, for the Granville Solvents Site PRP Group.
- U.S. EPA, January 2000. Fact Sheet on the Proposed Plan of the Non-Time Critical Removal Action at the Granville Solvents, Inc. Site, Granville, Ohio.
- U.S. EPA, March 8, 2000, Enforcement Action Memorandum, United States Environmental Protection Agency, Region V, March 8, 2000

2.0 SITE DESCRIPTION AND BACKGROUND

The Site is the location of an inactive waste solvent blending and recycling operation at 300 Palmer Lane in Granville, Licking County, Ohio (Figure 1). The Site is near the southern corporate limit of the Village of Granville, but within the Village boundaries, located approximately one-third of a mile southeast of downtown Granville. The Site is on a 1.5-acre triangular-shaped parcel located adjacent to a residential area, with some commercial and light-industrial business nearby. The Site is bordered on the northwest by Palmer Lane which slopes downward southwest toward the municipal well field. A former railroad track, now a bike and walking path, is the southern border of the Site with the Cherry Street overpass bordering the Site on the east. Raccoon Creek is located approximately 100 feet south of the walking and bike path. The Village of Granville municipal well PW-1 is located 700 feet west of the Site as shown on Figure 1. The Site is zoned for commercial use. The location of this Pilot Test is immediately to the east of the warehouse building. This location is presented on Figure 2.



Nonresponsive map showing municipal well locations

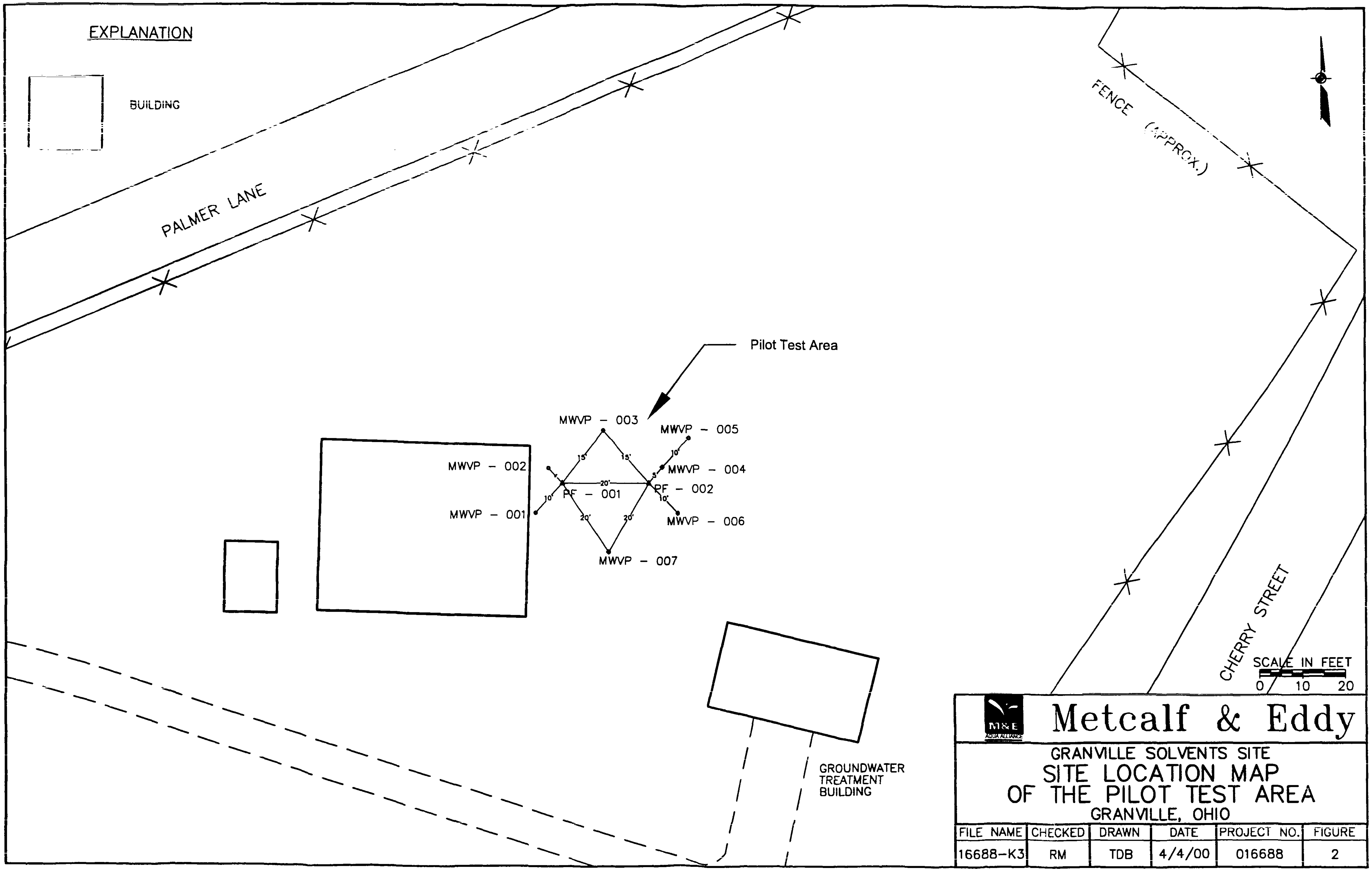
[redacted]

GRANVILLE SOLVENTS SITE

SITE MAP

GRANVILLE, OHIO

FILE NAME	CHECKED	DRAWN	DATE	PROJECT NO.	FIGURE
EECA-3	MR	TPF	4/4/00	016688	1



Metcalf & Eddy

GRANVILLE SOLVENTS SITE
SITE LOCATION MAP
OF THE PILOT TEST AREA
GRANVILLE, OHIO

FILE NAME	CHECKED	DRAWN	DATE	PROJECT NO.	FIGURE
16688-K3	RM	TDB	4/4/00	016688	2

3.0 GEOLOGIC SETTING

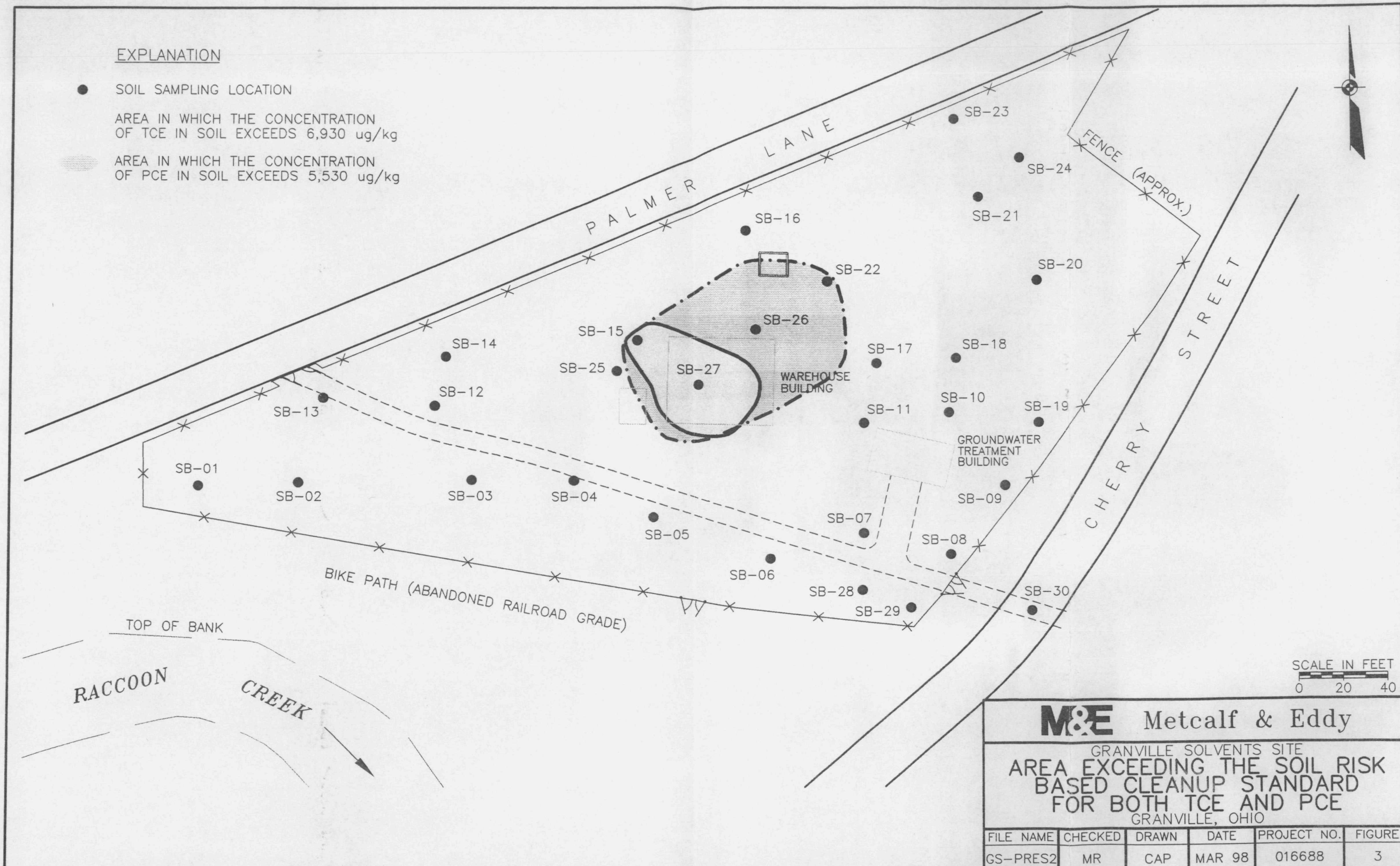
The Site is located on alluvial terrace deposits at the northern edge of Raccoon Creek Valley. The Site is directly underlain by clay-, silt- and sand-rich sediments deposited on the Raccoon Creek floodplain. Below the surficial material is a highly permeable sand and gravel outwash. The finer-grained surficial materials may retard but do not form a hydraulic barrier to the infiltration of precipitation from the surface. Based on the well logs of the monitoring and production wells, a typical vertical section may be simplified as a low permeability unit of interbedded fine-grained sand, silt, and clay lenses from the ground surface down to the water table (approximately 20 feet below the surface, typically, at 900 feet amsl). Extending beneath the water table, the aquifer consists chiefly of fine- to coarse-grained sand and silt, interbedded with gravel lenses of various thicknesses. Those compounds with a tendency to bind to clay particles and organic carbon are inhibited from downward movement. However, percolation of precipitation downward results in the slow transport of these compounds into the saturated zone.

4.0 NATURE AND EXTENT OF CONTAMINATION

Volatile organic chemicals of concern are those listed in Table 1. Those substances were detected in soil in and around the immediate vicinity of the warehouse building (Figure 3). The distribution of these compounds in the soil takes the shape of an inverted cone, with the smallest area of impact at or near the surface and the larger area of impact at or near the water table.

TABLE 1
VOLATILE ORGANIC CHEMICALS OF CONCERN IN
SOIL AT THE GRANVILLE SOLVENTS SITE

1,1,1-Trichloroethane	Chlorobenzene
1,1,2-Trichloroethane	Chloroform
1,1-Dichloroethane	Ethylbenzene
1,1-Dichloroethene	Methylene chloride
cis-1,2-Dichloroethene	Tetrachloroethene
trans-1,2-Dichloroethene	Toluene
2-Butanone	Trichloroethene
Acetone	Vinyl chloride
Benzene	Xylenes
Carbon disulfide	



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GRANVILLE SOLVENTS SITE
AREA EXCEEDING THE SOIL RISK BASED CLEANUP STANDARD FOR BOTH TCE AND PCE
GRANVILLE, OHIO

FILE NAME	CHECKED	DRAWN	DATE	PROJECT NO.	FIGURE
GS-PRES2	MR	CAP	MAR 98	016688	3

5.0 TECHNOLOGY BACKGROUND

Pneumatic fracturing is a patented, innovative technology which enhances the in-situ removal and treatment of hazardous organic compounds in low permeability soil and rock formations. The principal objectives of pneumatic fracturing are reduction in treatment time and extension of available technologies to more difficult geologic conditions. Pneumatic fracturing has been successfully integrated with in-situ treatment technologies such as vapor extraction, bioremediation and ground water contaminant recovery.

Pneumatic fracturing typically involves the injection of pressurized air into low-permeable soil to extend existing fractures and to create a secondary network of conductive subsurface fissures and channels. The enhanced network of fractures increases the exposed surface area of the contaminated soil, as well as its permeability to liquids and vapors, thus creating pathways that enhance the Soil Vapor Extraction (SVE) process.

With SVE, air flow is induced through contaminated soil by applying a vacuum to vapor extraction vents and creating a pressure gradient in the vapor-phase within the vadose zone of the targeted soil. As the soil vapor migrates through the soil pores toward the extraction vents, VOCs are volatilized, transported out of subsurface soil, collected above ground, and, if necessary, treated before release. SVE system performance depends on properties of both the soil (air permeability, bulk density, porosity, and moisture content) and the contaminants (vapor pressure, water solubility, melting point, boiling point, and sorption properties). The most important soil property is air permeability, and the most important contaminant property is vapor pressure.

Because of the low permeability of the targeted subsurface soil at the Granville Solvents Site (GSS), the application of SVE without any enhancements is not considered feasible. However, used in conjunction with technologies that enhance permeability or volatility, the potential effectiveness of SVE can increase to the point that it becomes a viable and cost effective remedial alternative for VOC contamination in the unsaturated zone.

6.0 PILOT TEST OBJECTIVES

The objectives of the pilot test are to: (1) evaluate the influence of pneumatic fracturing on the soil formation and (2) evaluate its potential to enhance remedial efforts in contaminated areas prior to, during and after fracturing activities. The following four parameters will be monitored:

- Natural or pre-fracture baseline bulk air permeability and mass removal rates
- Pressure requirements for fracture initiation and maintenance
- Extent of fracture propagation and orientation
- Post-fracture bulk air permeability and contaminant mass removal rates.

The following is a discussion of each of these parameters.

6.1 PERMEABILITY TESTING

6.1.1 Extraction Flowrate

A characteristic of a formation for effective contaminant removal is its natural bulk air permeability. One of the effects of fracturing a dense geological formation is an increase in the bulk permeability. As a direct result, the potential removal of volatile contaminants when combined with a system such as SVE is increased. A quantitative comparison of air flowrate before and after fracturing will be done to provide an indication of the relative effectiveness of fracturing at the GSS to enhance contaminant removal.

6.1.2 Extraction Radius of Influence

In addition to the increased extraction flowrate, pneumatic fracturing also provides a method to reduce heterogeneity within the formation. The radius of vacuum influence during permeability testing demonstrates the degree of influence of the SVE system. A comparison of pre- and post-fracture vacuum influence will be done. Through construction of a pilot test area with monitoring points screened within the target fracture zone, an assessment can be made on the horizontal permeability changes. This information will be used in the evaluation of pneumatic fracturing at GSS for enhanced contaminant removal.

6.1.3 Contaminant Mass Removal

Contaminant mass removal will be determined by monitoring extraction flowrate and VOC concentrations at specific times during each of the two permeability tests. Vapor samples will be collected and analyzed hourly during the pre-fracture permeability test and six times per day during the post-fracture permeability test. Total VOC concentrations in the vapor samples will be recorded with a hand-held HNU Model DI-101 Data Logging Photoionization analyzer. This information will be used in the evaluation of pneumatic fracturing at GSS for enhanced contaminant removal.

6.2 PNEUMATIC FRACTURE INJECTIONS

6.2.1 Fracture Radius of Influence

Fracture propagation is a function of the natural stresses and strains in the formation and the effective rate of "leak-off" of the gas into the formation. Pressure influence at surrounding monitoring wells will be monitored during fracturing so that the effective radius of fracture influence can be determined. This information will be used in the subsequent design of the full-scale application to layout extraction well spacing.

6.2.2 Fracture Pattern and Orientation

The paths of fracture propagation/creation are used to verify the horizontal extent of permeability change. Through the use of monitoring points screened within the targeted fracture zone and located in varying radial distances from the fracture well, an assessment of the induced fracture network can be accomplished.

6.2.3 Ground Surface

Measurement of ground surface heave or "ground uplift" during fracture injections is a monitoring technique utilized in the oil field to determine fracture orientation and distances. This same concept holds true for shallow fracture applications. Using a surveying transit and a graduated tape which is attached to a pylon located at the fracture well, measurement of the ground deflection can be monitored during each pneumatic injection. The maximum amount of upward motion (surface heave) and final ending height (residual heave) is recorded. The ground surface heave will provide direct evidence of fracture propagation and direction.

7.0 PILOT TEST APPROACH

The operations that will be involved with the pilot test at the GSS are discussed below.

7.1 PROJECT HEALTH AND SAFETY PLAN

The Health and Safety Plan will address safety issues specific to Pneumatic Fracturing and SVE operations and general health and safety issues. Site personnel shall be familiar with this document prior to executing the pilot test work on the GSS site.

7.2 WELL INSTALLATION

Two pneumatic fracture wells and seven monitoring wells will be installed at the pilot test area at the site. The layout of the wells is presented in Figure 4. Two fracture wells will be installed to a depth of 15 feet bgs. The construction details of the fracture wells are presented in Figure 5. Seven monitoring wells will be installed to a depth of 15 feet bgs. The construction details of the monitoring wells are presented in Figure 6.

7.2.1 Fracture Wells

Two pneumatic fracture wells will be installed within the pilot test area. Previous site investigations have identified the geology within the targeted fracture interval (approximately 5 to 15 feet) to consist primarily of silt-rich clays. Based upon this information, it is anticipated that the two 4.75-inch-diameter bore holes will be advanced to an approximate depth of 15 feet bgs utilizing solid stem augers. Drilling contractors are requested to use augers and drill bits with an outside diameter capable of creating a hole diameter of 4.75 inch to ensure the hole size is close to, but not larger than, 5 inches in diameter.

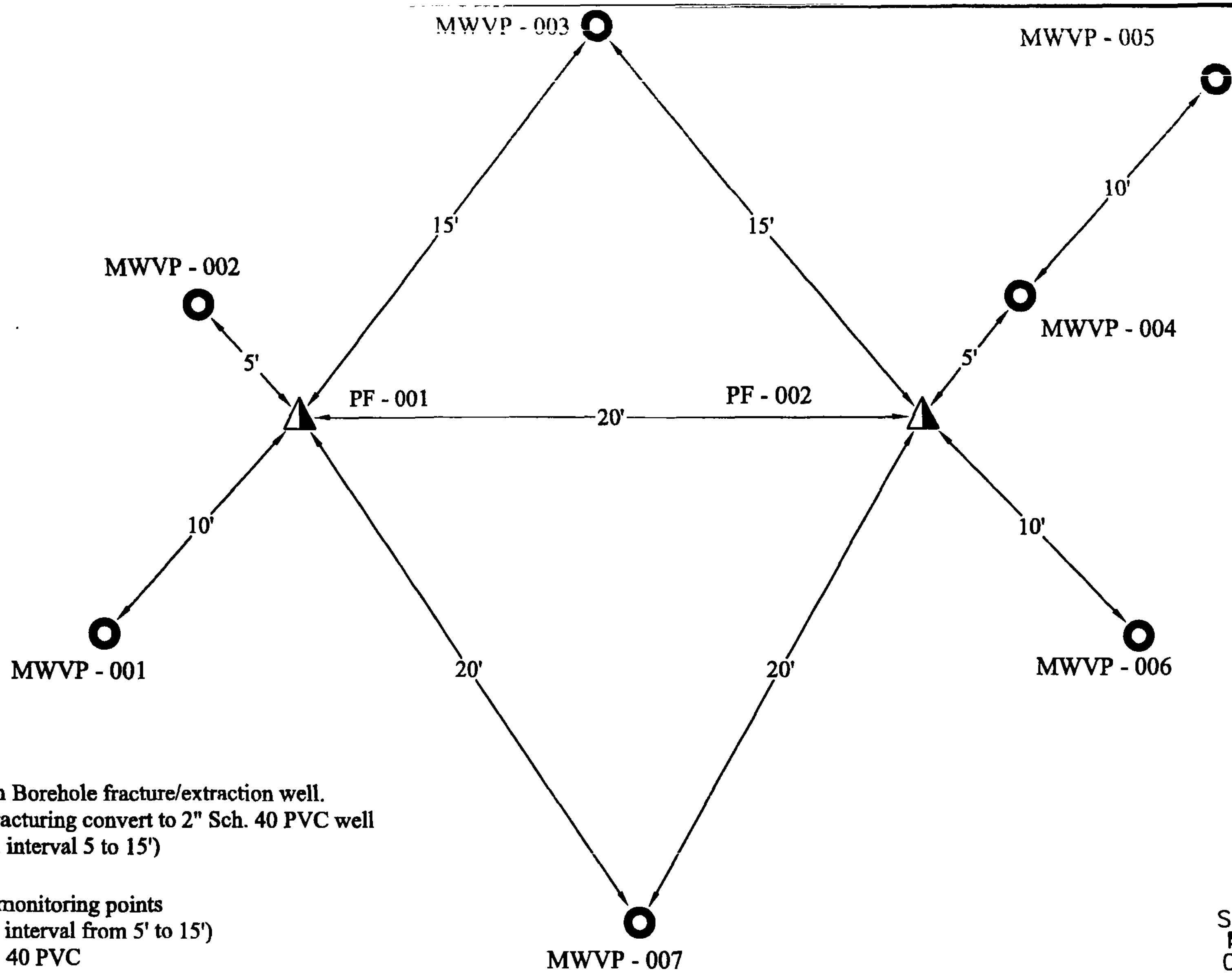
Given the clay consistency and cohesiveness of the site soils, the two borings are expected to remain open for the duration of the pre-fracture permeability tests and the pneumatic fracture operations. Once the fracture applications are completed, both borings will be converted to 2-inch, schedule 40 PVC extraction wells.

7.2.2 Monitoring Wells

Seven monitoring wells will be installed within the pilot test area and will be designed to monitor both pressure and extraction influence within the targeted fracture zone. The wells will be constructed by first drilling a 5-inch-diameter boring to a depth of 15 feet bgs and then inserting a 2-inch, schedule 40 PVC well screen (0.02 slot). The well screen will consist of a 10-foot screened interval and a 7.5-foot long riser pipe. No. 2 sand will be used around the annular space of the screened interval. A bentonite/Portland One cement mixture will be placed around the riser pipe to seal off the screened interval. A monitor well construction detail is included as Figure 5. During the installation of two monitoring wells, adjacent to each fracturing well, continuous split-spoon sampling will occur from a depth of 5 feet to 15 feet bgs. The soil samples will be used for geologic logging purposes and for VOC screening. VOC concentrations will be field screened with a portable PID (HNU Model DL-101).

7.3 BULK AIR PERMEABILITY TESTING

Prior to permeability testing, the baseline behavior of the formation will be characterized. Before initiating the test, an overall system check will be performed. This will consist of checking to see that the blower is operating properly, that vacuum gauges are operational and calibrated, and an initial vacuum response will be measured at each monitoring point. This vacuum response check is conducted with the blower unit, and is necessary to ensure that the proper range of the Magnehelic™ vacuum gauges are available at each monitoring location prior to starting the pre-fracture extraction test. The vacuum gauges on the monitoring wells will be tagged indicating the date of calibration and an instrumentation calibration log sheet will be included in the equipment operations manual on site during the testing.



LEGEND:

5" Open Borehole fracture/extraction well.
After fracturing convert to 2" Sch. 40 PVC well
(Screen interval 5 to 15')

Vapor monitoring points
(screen interval from 5' to 15')
2" Sch. 40 PVC

SCALE IN FEET
0 2.5 5

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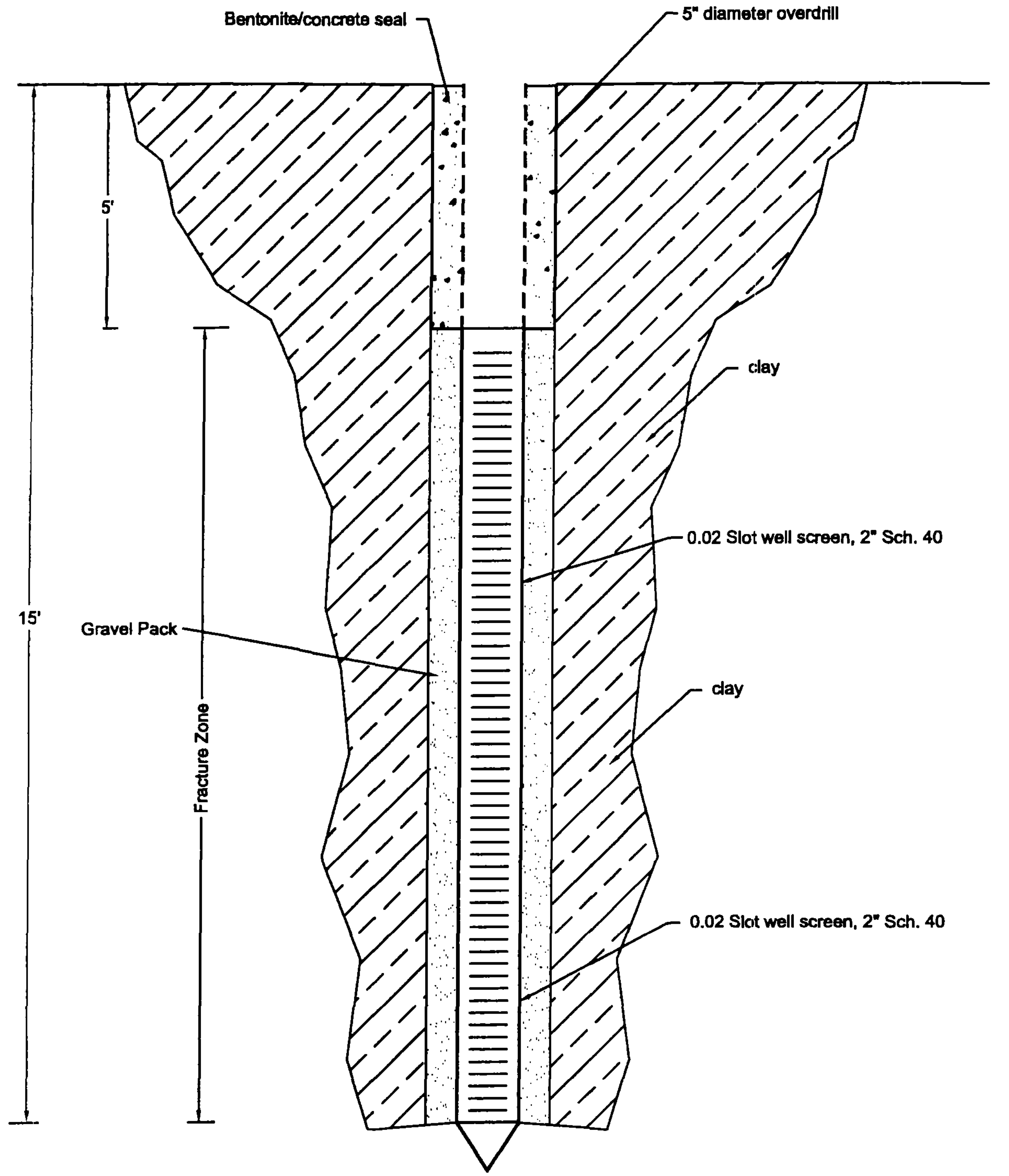
GRANVILLE SOLVENTS SITE
TYPICAL WELL LAYOUT FOR PILOT TEST AREA
GRANVILLE, OHIO

Project Number 16688	
File Name 16688–K1	Figure 4



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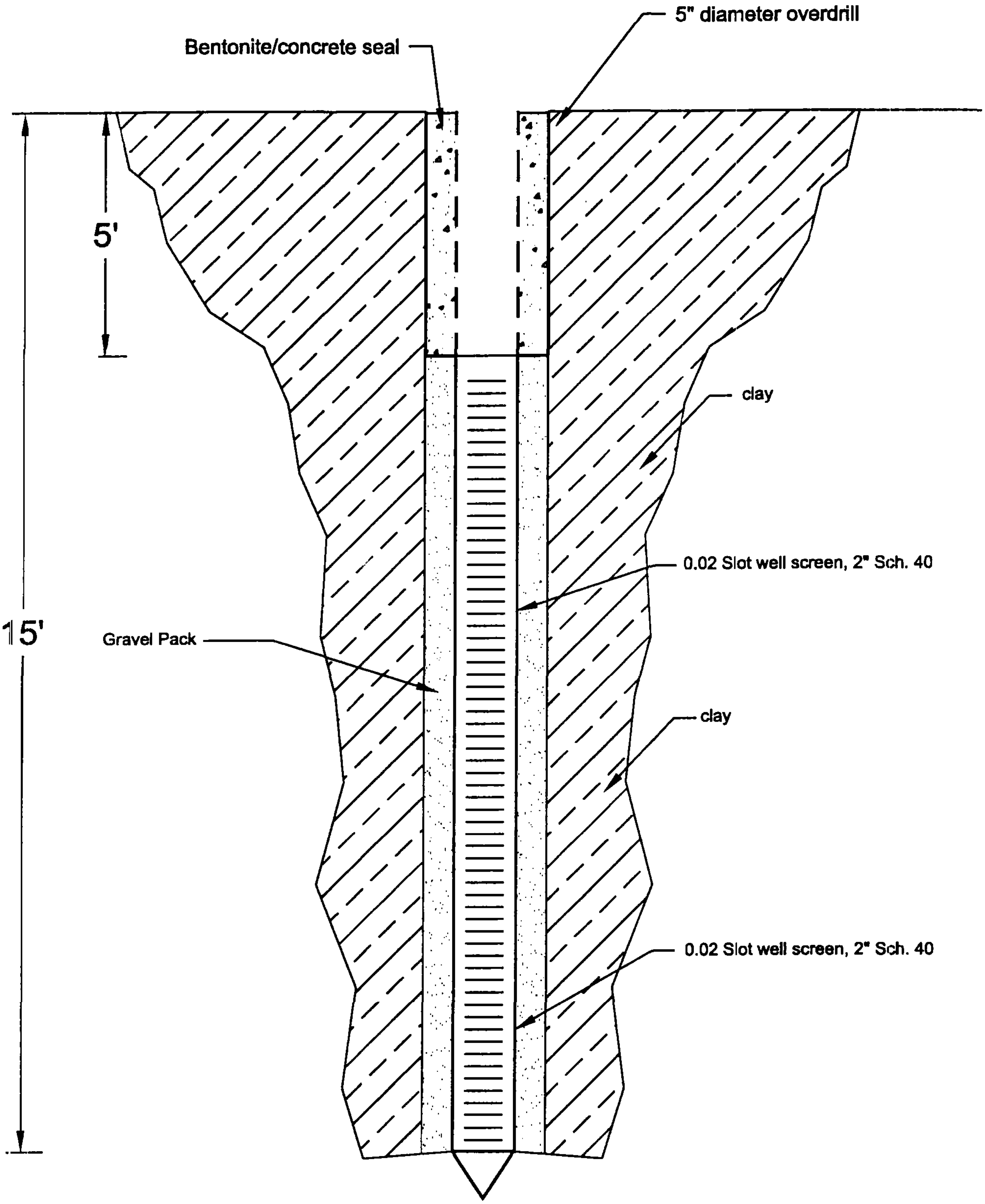
GRANVILLE SOLVENTS SITE
FRACTURE WELL CONSTRUCTION DESIGN
GRANVILLE, OHIO

Project Number	
16688	
File Name	Figure
16688-K2	5



NOT TO SCALE

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GRANVILLE SOLVENTS SITE
MONITORING WELL
CONSTRUCTION DETAIL
GRANVILLE, OHIO

Project Number	
16688	
File Name	Figure
16688-K5	6

7.3.1 SVE Equipment Specifications

The vacuum blower will be skid-mounted and consist of a 10-horsepower positive displacement blower capable of producing a vacuum of up to 13 inches of mercury and extraction air flow volumes up to 100 cfm. The unit comes equipped with a 55-gallon water knock-out tank with transfer pump, high liquid level shutdown, both pressure relief and vacuum relief valves, and electrical wiring, thermal overloads, piping, and vacuum gauging to monitor process parameters. Instrumentation will include two air flow measurement devices, a Merrium Annubar, Erdco temperature gauges, and magnahelic pressure gauges. In addition, two 175-lb vapor phase carbon units will be mobilized to the site for off-gas vapor treatment. A process schematic for this pilot test equipment is included as Figure 7.

What kind of testing to show no break-thru?

7.3.2 Pre-Fracture Soil Vapor Extraction Testing

The pre-fracture permeability test will involve extracting air from a selected monitoring well via a vacuum blower. The extraction test will be run for approximately 6 hours, during which the vacuum influence at the surrounding monitoring wells and adjacent pneumatic fracture wells will be monitored. The vapor flow-rate, total vacuum, and total volatile organic concentration at the test well will also be monitored.

What are air emission limits in Ohio?

7.3.3 Groundwater Pumping System

To maintain groundwater at a constant level within the extration wells and prevent mounding due to the induced vacuum, a groundwater pumping and monitoring system will be used during the pilot test. The system will include an interface probe to monitor water levels in surrounding monitor wells, two pneumatic bladder pumps, an air compressor with necessary controls/filter assemblies and ground water flow totalizers. The groundwater pumped from the extraction wells will be transferred to and treated by the existing treatment plant at the site.

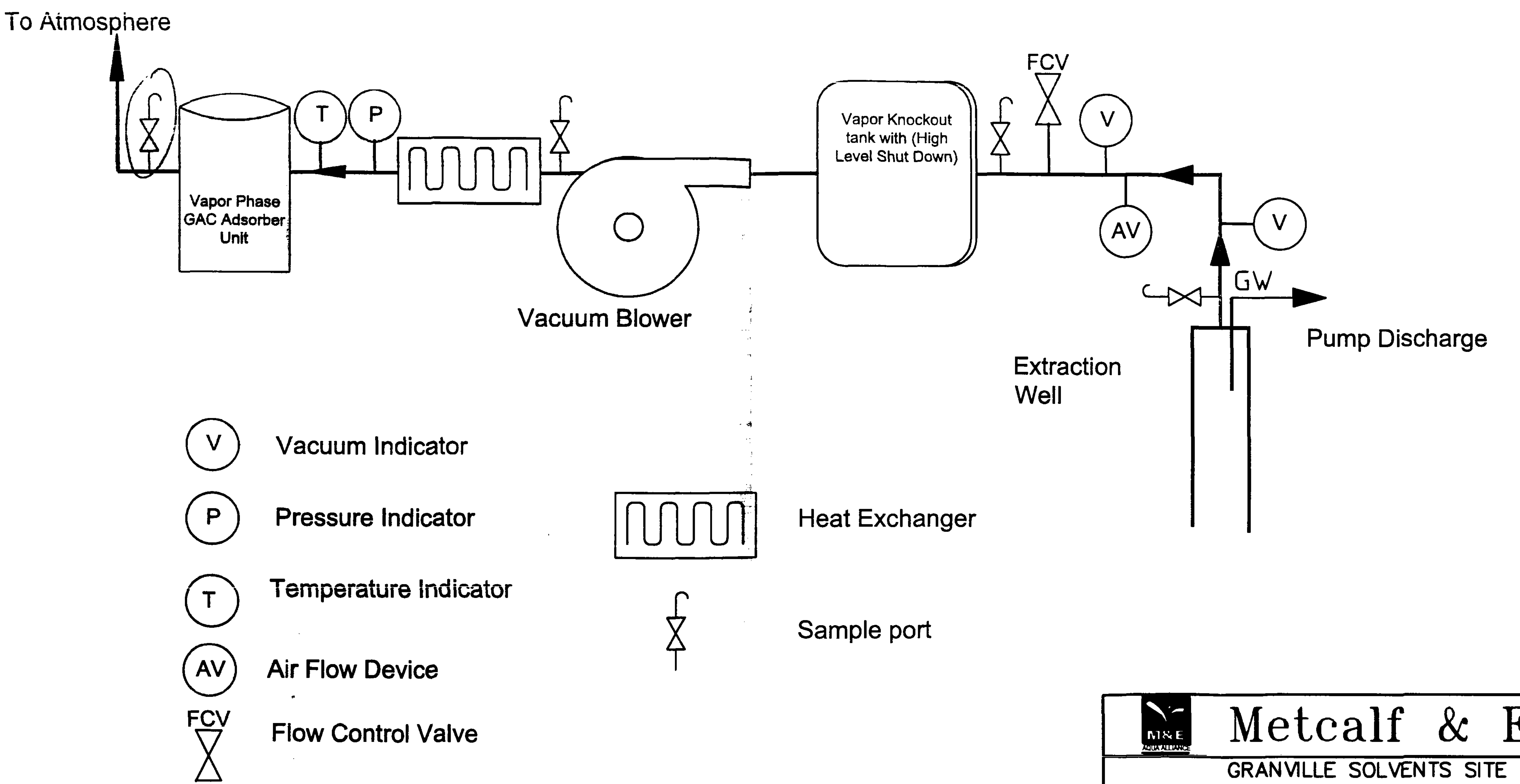
7.4 PNEUMATIC FRACTURING

ARS Technologies' proprietary application and monitoring equipment for the pneumatic fracturing extraction process is contained within a 20-foot injection trailer. This commercial pneumatic fracturing extraction injection trailer consists of a compressed air unit, pressurized storage unit and injection control manifold. A remote control unit allows safe operation of the unit from as much as 50 feet from the trailer. The injection manifold allows for the accurate control of injection pressure and flow. The built-in safety interlocks prevent the inadvertent discharge of air and ensure that the air is injected at the specified process parameters.

The injection trailer is connected by a high pressure hose to the air injector. The air injector is typically lowered into a borehole or well and activated to pack-off an isolated discrete zone of the borehole. Downhole air is continuously monitored by a pressure transducer that is located inline and transmits pressure measurements to a data acquisition system on the surface. The downhole injection pressure is a critical measurement which determines the pressure at which the formation yields or breaks.

Downhole monitoring will provide fracture initiation and fracture maintenance pressures in the formation during the injection process. This data will be acquired with a pressure transducer located within the flow path of the pressurized gas, and logged with a data acquisition system. Based upon previous pneumatic fracture injections performed within similar geology, we expect initiation pressures to range from 50 to 75 psi. Ground heave data will be obtained during and after each injection using surveying transits.

ARS Technologies will implement pneumatic fracture injections within the two designated fracture borings in 2- to 3-foot increments. Each injection will last 15 seconds. A total of 20 feet (2 wells) of strata, at depths of 5 to 15 feet, will be fractured. During each pneumatic injection, the following system operational data will be collected: pneumatic pressure influence in surrounding monitoring wells, ground surface heave, and downhole injection pressure. These parameters will provide data which will be utilized to evaluate the orientation and propagation of fractures.



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GRANVILLE SOLVENTS SITE

PROCESS SCHEMATIC FOR PILOT TEST EQUIPMENT

GRANVILLE, OHIO

FILE NAME	CHECKED	DRAWN	DATE	PROJECT NO.	FIGURE
16688-K6	MA	FGS	4/4/00	016688	7

7.4.1 Fracture Initiation/Maintenance Pressures

A pressure transducer located within the pressurized gas flow path is used to record a pressure-time history during fracturing. The maximum pressure peak read from its LCD read-out represents the pressure at which the formation fails (or fractures). Another parameter that the transducer logs is the fracture maintenance pressure, which correlates with the depth of fracturing. An additional pressure gauge is located at the fracture well-head, which will be used to compare with the pressure data collected by the transducer.

7.4.2 Pressure Influence at Monitoring Points

Pressure influence data taken from the monitoring points during fracture injections will provide an indication of the fracture pathway. By comparing the maximum pressure obtained from the target zone with the maximum pressure obtained at each monitoring point, it can be determined in what direction fracture propagation occurred.

7.4.3 Ground Surface Heave

Ground surface heave will be measured during each injection using surveying transits. A graduated tape is attached to a pylon located at the well being fractured and its deflection is observed during each pneumatic injection. The maximum amount of upward motion (surface heave) and final ending height (residual heave) is recorded. The maximum heave will provide information relevant to the effects of fracturing on structure integrity. The residual heave is used at shallow depths to determine the cumulative apertures of fractures created.

7.5 POST-FRACTURE PERMEABILITY TESTING

To evaluate the effectiveness of pneumatic fracturing in enhancing the permeability within the pilot test area, a post-fracture extraction test will be conducted. The test will run for 30 days, in the same manner as the pre-fracture test. The extended 30-day test will allow the system to achieve near steady state conditions, based on which a full-scale system can be designed.

7.6 PERFORMANCE ASSESSMENT

To evaluate the effectiveness of pneumatic fracturing, permeability data before and after injections will be compared. Bulk permeability values will be collected for both the pre-fracture and post-fracture tests. The extraction radius of influence will be determined through the vacuum influence data collected during these same tests.

7.7 REPORT PREPARATION

At the completion of all field activities, a pilot test report will be submitted to U.S. EPA incorporating the results and conclusions pertaining to the pilot test operations. Design parameters will be calculated.